BR($h \to \tau^+\tau^-$) Study Status

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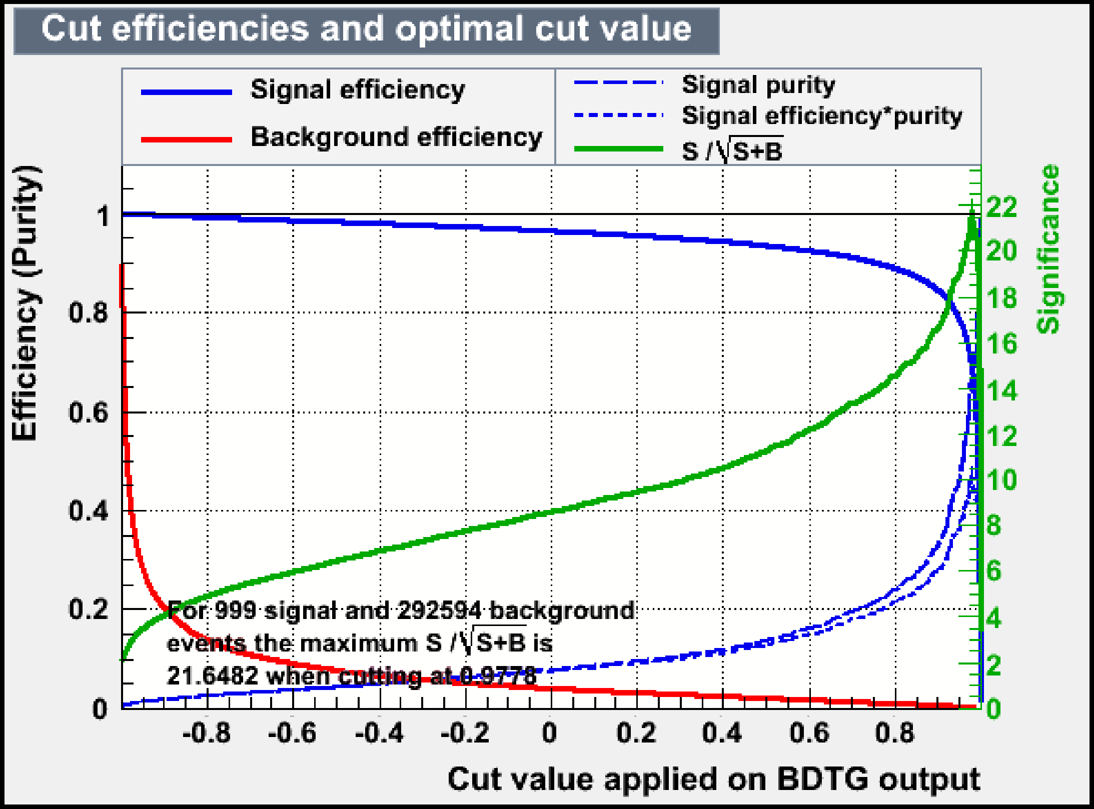
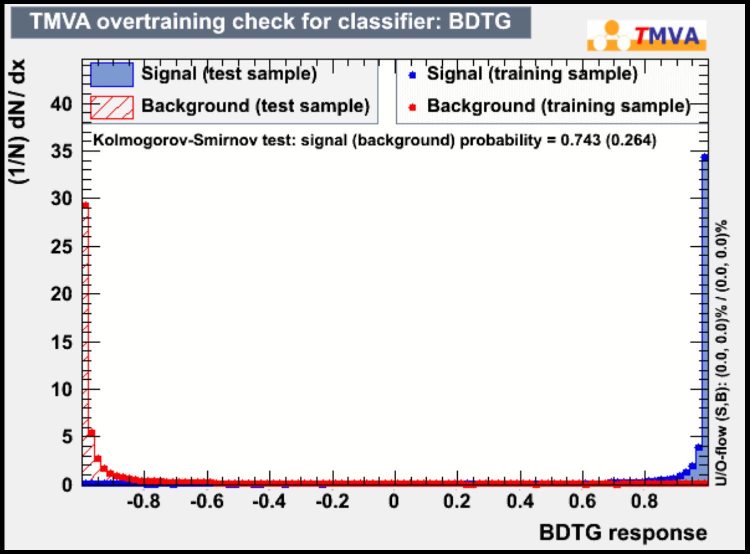
qqh500 Analysis with TMVA

- TMVA(BDTG) analysis has been performed.
- 14 variables
  - E_{vis}、P_t、 $P_t(\mathrm{all})$
  - M_Z、 E_Z、$\cos\theta_{q\bar{q}}$、$\cos\theta_Z$
  - $M_{\tau\tau}$、$\cos\theta_{\tau\tau}$、$\cos\theta_{\mathrm{acop}}$、$d_0$sig、$z_0$sig
  - M_{col}、E_{col}
- Training parameters
  - nCuts = 45, Shrinkage = 0.20, MaxDepth = 3, NTrees = 300, nEventsMin = 250

Result





$N_{sig} = 695.1$, $N_{bkg} = 335.8$

$$\frac{S}{\sqrt{S+B}} = 21.6\sigma \leftrightarrow \frac{\Delta(\sigma \times \mathrm{BR})}{(\sigma \times \mathrm{BR})} = 4.6\%$$

Summary

	Cut-based	TMVA
Significance	20.1σ	21.6σ
$\frac{\Delta(\sigma \times \mathrm{BR})}{(\sigma \times \mathrm{BR})}$	5.0%	4.6%

relatively ~7% better in TMVA
not so changed from previous results (4.7%)

Next:
- analysis of other modes (nnh, eeh, mmh)
- more study of tau finder
  --- current eff. is 49.8% (reconstructed 1 tau+ & 1 tau-)
  --- eff. of 1 tau+(tau-) reconstruction = 70.6%(70.6%)

BACKUP

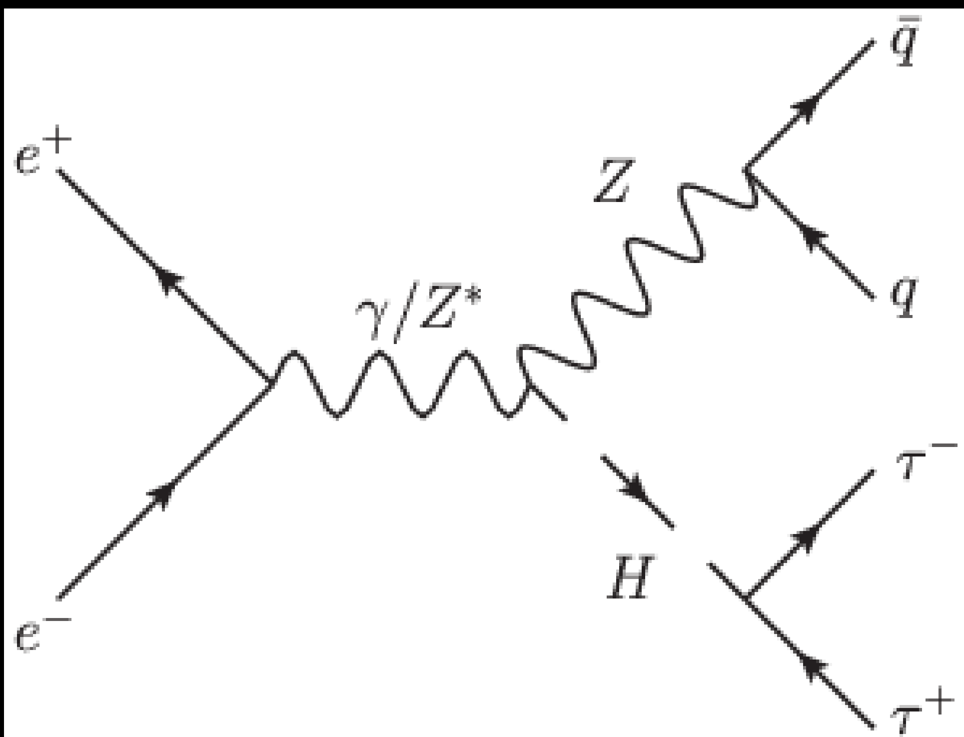
Signal & Background

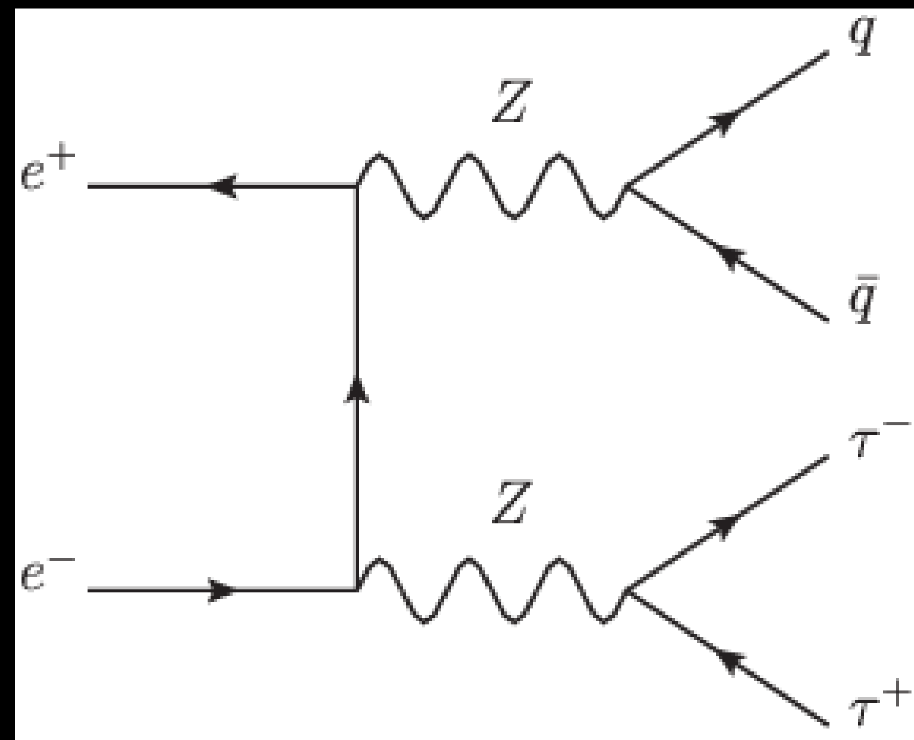
Signal

$e^+e^- \rightarrow Zh \rightarrow q\bar{q}\tau^+\tau^-$

Main Background

$e^+e^- \rightarrow ZZ \rightarrow q\bar{q}\tau^+\tau^-$





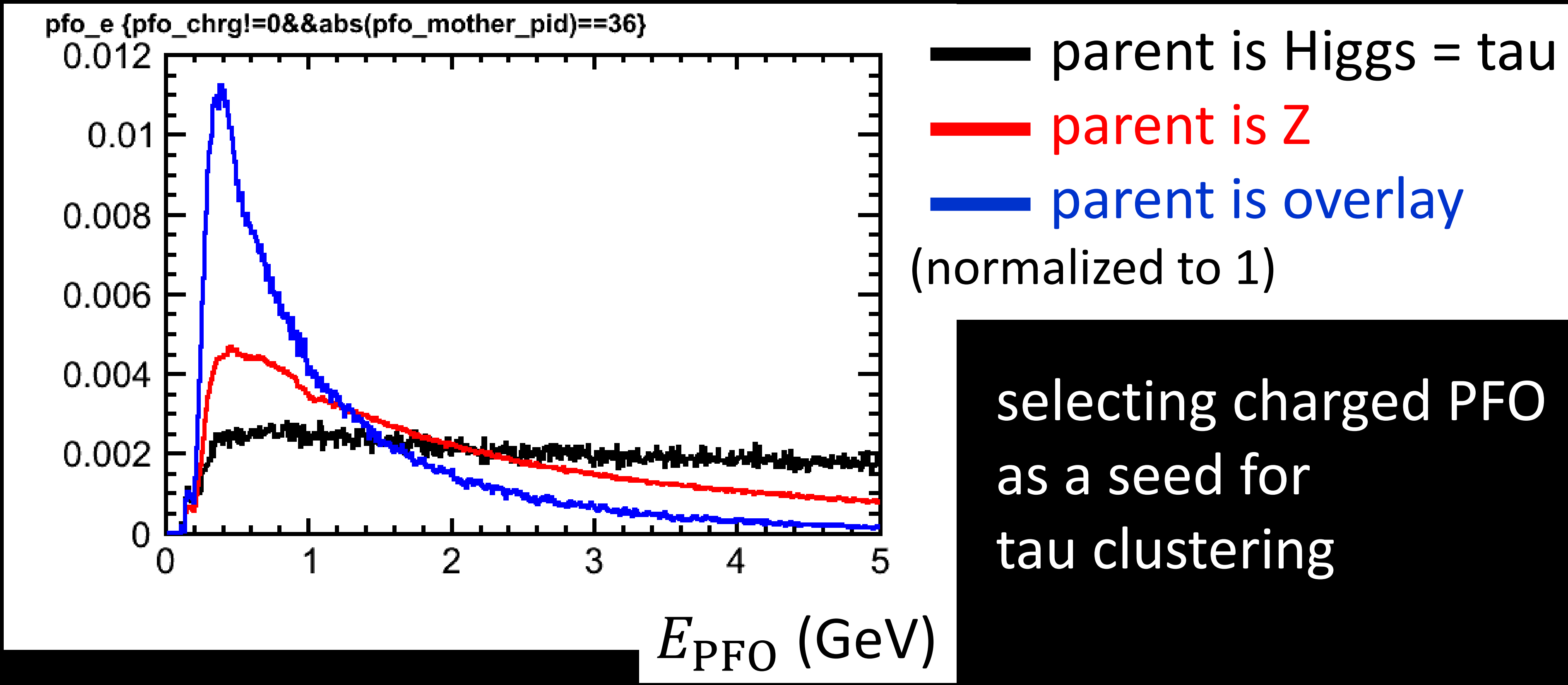
Simulation Samples (500 GeV)

- generated signal samples (w/ proper tau pol.)
- available DBD (TDR) samples
  - 2f, 4f, 5f, 6f, aa_4f, higgs_ffh
- aa_2f SGV samples

Event Reconstruction

- Previous procedure: (1) kT-4, (2) tau finder, (3) Durham-2
  - But clustering is not perfect. Some of the physics signal objects will be lost by applying kT clustering.
  - How to optimize kT?
- Current procedure now I'm trying: (1) tau finder, (2) kT-2, (3) Durham-2
  - need optimization of tau finder: do not reconstructing overlay objects as a tau jet
  - optimizing kT is easy & clear, using Z mass

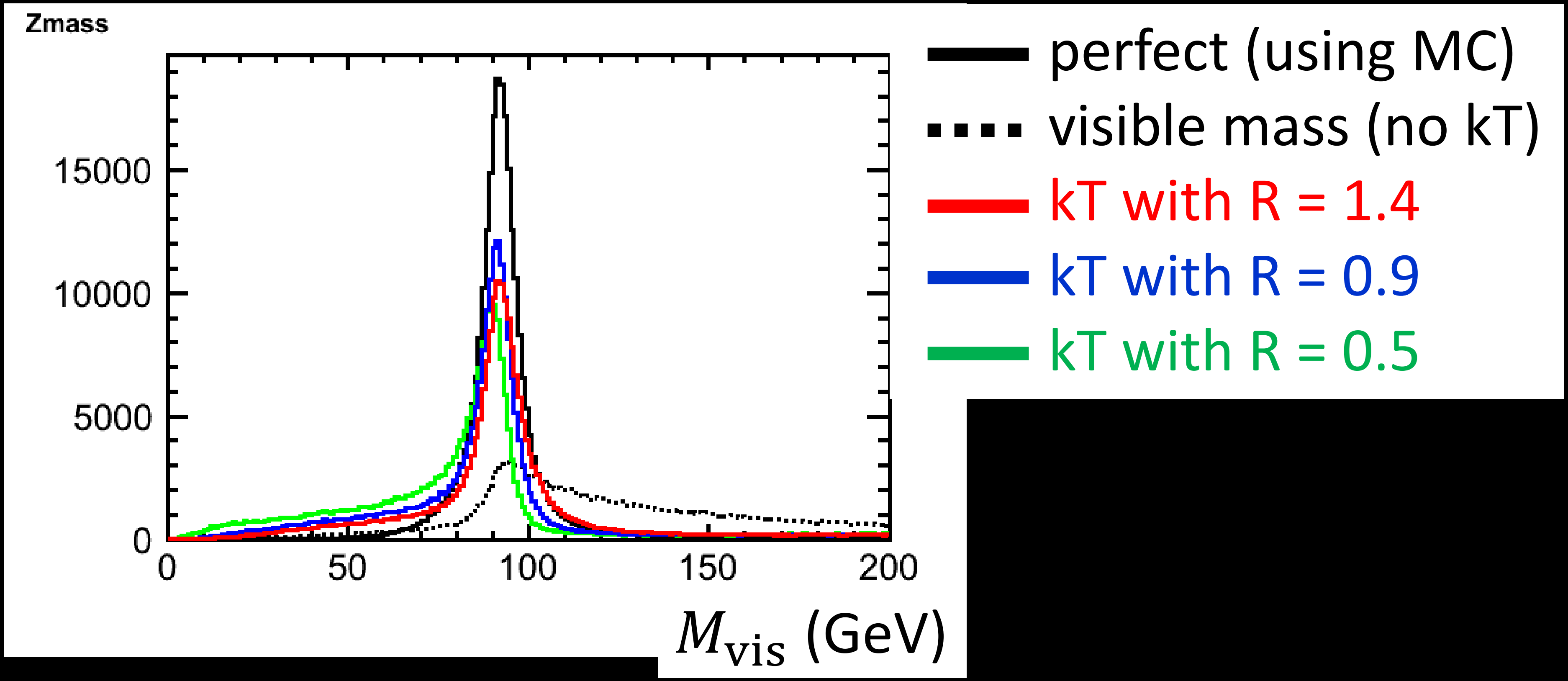
Optimization in Tau Finder: Example



selecting charged PFO as a seed for tau clustering

Low energy particles are almost overlay objects (and from Z).
I decided the threshold for seeds as $E_{\mathrm{PFO}} > \mathbf{2\ GeV}$.

Optimizing kT clustering



Plot of the visible mass after tau selection.
(Z mass) = (visible mass after tau selection) for ideal, but contaminated by overlay objects.
I checked R = 0.5 - 1.4 (every 0.1), $\boldsymbol{R = 0.9}$ was optimum.

Cut-based Analysis: Cut Flow

Cut 0 (pre-cuts): # of q = 2, # of $\tau^{+(-)}$ = 1
Cut 0.5 (basic cuts):
8 <= # of tracks <= 70, $140 < E_{\mathrm{vis}} < 580$, $110 < M_{\mathrm{vis}} < 575$,
$P_t > 60$, thrust < 0.99, $E_{\tau\tau} < 320$, $M_{\tau\tau} < 300$, $\cos\theta_{\tau\tau} < 0.65$,
$50 < E_Z < 395$, $10 < M_Z < 375$, $30 < E_{\mathrm{col}} < 450$, $5 < M_{\mathrm{col}} < 360$
Cut 1: # of tracks <= 67
Cut 2: $P_t(\mathrm{all}) > 5$
Cut 3: thrust < 0.94
Cut 4: $|\cos\theta_{\mathrm{thrustaxis}}| < 0.86$
Cut 5: $|\cos\theta_{\mathrm{miss}}| < 0.99$
Cut 6: $\cos\theta_{\tau\tau} < 0.56$
Cut 7: $\log_{10}|d_0\mathrm{sig}(\tau^+)| + \log_{10}|d_0\mathrm{sig}(\tau^-)| > -0.3$
Cut 8: $\log_{10}|z_0\mathrm{sig}(\tau^+)| + \log_{10}|z_0\mathrm{sig}(\tau^-)| > 0.3$
Cut 9: $E_Z > 190$
Cut 10: $70 < M_Z < 110$
Cut 11: $110 < M_{\mathrm{col}} < 140$ ← cut for collinear approximation: most important in this case

Cut Table & Results

表 1　500 GeV $q\bar{q}h$ Cut-based 解析の cut table。eX は $\times 10^X$ を表す。

	qqh $h \to \tau\tau$	qqh $h \not\to \tau\tau$	$\nu\nu h$ $\ell\ell h$	2f	4f	5f	6f	aa_2f	aa_4f	sig.
None	2131	3.260e4	9.397e4	1.320e7	1.598e7	6.895e4	5.888e5	9.829e8	1.041e5	0.0669
pre	1014	691.4	5223	8.181e5	6.224e5	6440	2.886e4	1.583e6	9619	0.578
basic	998.9	357.7	2631	5.919e4	1.781e5	3956	2.042e4	2.567e4	2273	1.84
# tracks	998.6	353.8	2628	5.916e4	1.780e5	3947	2.005e4	2.567e4	2270	1.84
P_t(all)	991.5	299.4	1972	3.636e4	1.375e5	3059	1.886e4	2.219e4	1695	2.10
thrust	978.8	297.3	1955	2.138e4	7.974e4	2999	1.881e4	1.220e4	1653	2.62
$\theta_{\mathrm{thrustaxis}}$	883.2	273.8	1458	1.082e4	3.628e4	1388	1.476e4	4056	668.4	3.32
θ_{miss}	875.6	259.9	1330	9066	3.273e4	1245	1.444e4	3863	543.0	3.45
$\theta_{\tau\tau}$	872.5	232.9	874.9	8425	3.038e4	1216	1.404e4	3818	521.6	3.55
$d_0$sig	849.4	173.8	584.7	5861	2.028e4	726.0	9900	1586	334.0	4.23
$z_0$sig	784.9	109.1	230.2	3533	9256	165.6	5241	159.7	80.55	5.61
E_Z	697.8	86.72	155.6	2073	4542	36.28	2461	14.83	15.93	6.95
M_Z	610.5	19.13	34.03	176.3	1836	11.20	181.7	5.207	7.968	11.4
M_{colapp}	515.2	3.047	4.187	2.634	116.9	1.718	15.21	0	0	20.1

remained N_{sig} = 515.2, N_{bkg} = 143.7

$$\frac{S}{\sqrt{S+B}} = \mathbf{20.1\sigma} \leftrightarrow \frac{\Delta(\sigma \times \mathrm{BR})}{(\sigma \times \mathrm{BR})} = \mathbf{5.0\%}$$

not so changed than previous (4.9%)